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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

THE MODERN BUS AND TRUCK

Fuels and Lubricants
Part II

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

Photo courtesy Mack Trucks, Inc.

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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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THE MODERN BUS AND TRUCK

Fuels and Lubricants

Part II

THIS article is a continuation of the discussion on fuels and lubricants for trucks and busses which was started in last month's issue of LUBRICATION wherein the fuel phase was covered.

MOTOR OILS

A half century ago little attention was given to the problems of lubrication in automotive engines. Many controversial thoughts existed with regard to the best way to provide lubrication but not much consideration was given to the quality of the engine oil to be used. Changing the crankcase oil was rarely done since crankcase deposit problems were non-existent. This was due mainly to the high oil consumption rates which prevailed in those days and cooler running crankcases because of their massiveness in relation to power output.

As engine design improved more severe operating conditions were imposed on the oil; then the importance of lubrication became evident. Until twenty years ago straight mineral oils were used almost exclusively as motor oils and the only characteristics that seemed to be of importance were viscosity and carbon residue. Shortly thereafter however, the trend in design and performance of automotive engines showed rapid increases in compression ratio and speed; then higher power outputs resulted, while engine size remained the same or in some cases even was reduced. Concurrently the high speed Diesel engine was introduced to the automotive field.

These developments presented many metallurgical and lubrication problems. The oil industry quickly took the lead along with some engine builders to develop motor oils to meet the more exacting engine demands. Since the inception of research and development work on motor oils, a vast background of knowledge on engine lubrication has been gained and has been frankly discussed in technical publications. Typical of this is the January 1952 issue of LUBRICATION on Modern Motor Oils.

Motor Oil Types

A considerable variety of motor oils were developed as a result of this trend. The differences among the various types available are of interest. Previous to 1945 oils were classified by the SAE number only, with respect to viscosity. In February, 1947 the SAE approved the use of the following nomenclature as set forth by the American Petroleum Institute through the Lubrication Committee of its

Division of Marketing.

"Regular Type — This term designates motor oil generally suitable for use in internal combustion engines under moderate operating conditions."

"Premium Type — This term designates motor oil having the oxidation stability and bearing corrosion preventive properties necessary to make it generally suitable for use in internal combustion engines where operating conditions are more severe than regular duty."

"Heavy Duty Type — This term designates motor oil having the oxidation stability, bearing corrosion preventive properties and detergent dispersant characteristics necessary to make it generally suitable for use in both high-speed Diesel and gasoline engines under heavy duty service conditions."

On April 29, 1952 the Board of Directors of the API formally approved a new system of service classifications and designations for lubricating oils for automotive type engines which are as follows, and which supersede the previously described types:

"Service MS—Service typical of gasoline or other spark ignition engines operating under unfavorable or severe types of service conditions and where there are special lubrication requirements for deposit or bearing corrosion control, due to operating conditions or to fuel or to engine design characteristics."

"Service MM — Service typical of gasoline and other spark ignition engines operating under moderate to severe service conditions, but presenting problems of deposit or bearing corrosion control when crankcase oil temperatures are high."

"Service ML — Service typical of gasoline and other spark ignition engines operating under light and favorable service conditions, the engines having no special lubrication requirements and having no design characteristics sensitive to deposit formation."

"Service DG — Service typical of Diesel engines in any operation where there are no exceptionally severe requirements for wear or deposit control due to fuel or to engine design characteristics."

"Service DS — Service typical of Diesel engines operating under extremely severe conditions or having design characteristics or using fuel tending to produce abnormal wear or deposits."

The engine operator must rely on the reputation of his oil supplier as to the quality of motor oils supplied to meet these service classifications. When heavy duty type oils are supplied their quality is assured by definite engine test requirements they must meet.

Early Heavy Duty Type Motor Oils

As engine demands on the lubricating oil became more exacting the oil industry along with some engine manufacturers developed additive type motor oils for this more severe engine service which was termed "heavy duty" service.

The U. S. Army's standardization program required, for simplication of the supply problem, an engine oil which would be suitable for all types of engines in all types of service. Based on the experience available on the satisfactory performance of these newly developed additive type motor oils in civilian automotive service they issued the U. S. Army Specification 2-104B in May 1943 for approval of motor oils for military use. This specification has been superseded by the MIL-O-2104 specification. The 2-104B specification was drawn up around a series of five laboratory engine tests which the oil industry was using to evaluate the oxidation resistance, corrosion prevention, detergency and wear resistance properties of motor oils. Subsequent experience indicated that these tests could be reduced to two which would provide the desired information. These are the CRC-L-4-949 test conducted in a six-cylinder Chevrolet engine which provides information on oxidation stability, corrosion resistance and engine cleanliness in gasoline service, and the CRC-L-1-545 test conducted in a Caterpillar single cylinder Diesel engine which provides information on ring sticking, wear and accumulation of deposits in Diesel service.

Caterpillar Superior Lubricants (Series 2)

Field experience soon indicated that the early heavy duty type oils were showing wide ranges of performance. Poorer performance was shown in engines of improved design, in equipment undergoing more severe operating conditions and when fuel characteristics were changed to provide greater yields. In particular an increase in use of supercharging led to a deposit problem in the ring zone and the use of higher sulfur content fuels increased deposits and wear in some engines.

This led to the development of a special supercharged single cylinder engine test procedure using a fuel of high sulfur content (1%) to evaluate oils with improved properties. The test is known as the Caterpillar 1D Supercharged Engine Test. After satisfactory performance in this test an oil is subjected to a multi-cylinder supercharged Diesel engine test and an extensive field test program using high sulfur fuels in both cases. Oils accepted by Caterpillar as satisfactory in all phases of testing are included in their list of "Superior Lubricants (Series 2)."

The oils in this classification are recommended primarily for supercharged Diesel engines using fuels with sulfur contents higher than 0.5%, however, these lubricants commonly called "Super Duty," "Super Lubricants," "Series 2," "Supple-

ment 2," and "Super Detergent" oils have been used in automotive engines with remarkably excellent performance.

Supplement 1 Oils of U. S. Army Specification 2-104B

The wide spread in performance quality between the old heavy duty type motor oils and Caterpillar Superior Lubricants (Series 2) oils suggested that an intermediate performance level could be developed to provide the required improvement with more economical compounding costs. The U. S. Army Ordnance Department by means of their requirements for Supplement List 1 under the 2-104B Specification issued in May 1949 established this performance level lubricant.

An oil to qualify must not only be satisfactory as a 2-104B lubricant but in addition must show satisfactory performance in the CRC L-1 Caterpillar single-cylinder Diesel engine test when using 1% sulfur content fuels.

The U. S. Army does not use the Supplement 1 specification for procurement but some purchasers still retain the specification.

Current Heavy Duty Oils

Since the performance of the old heavy duty type motor oils varied widely, it appeared reasonable that a higher performance level should be established for these lubricants. In this way they could be used in newly designed equipment without resorting to the Supplement 1 or Series 2 oils requiring costly additive materials which might be limited in supply in case of an increasing demand for these oils. The requirements of the L-1 engine test were made more severe in order to qualify motor oils at a higher performance level. The specification of the Diesel fuel to be used in conducting the L-1 test was changed so as to have a minimum sulfur content of 0.35% instead of the old 0.4% maximum sulfur content. This imposed a more severe operating condition for the lubricating oil to combat.

This version of the L-1 test was included in the MIL-O-2104 specification issued in August 1950 to supersede the U. S. Army Specification 2-104B. Currently motor oils meeting this higher performance level are generally available and reliable marketers now generally classify their motor oils as heavy duty oils only when they qualify at this performance level.

Army policy at present is to list only qualified MIL-O-2104 oils without differentiation. Those having a legitimate need for this list will be supplied with it but it may not be published as an Ordnance list or with qualification numbers shown.

TABLE IV
Old Crankcase Oil Classification
(Dropped April 3, 1952)
SAE Recommended Practice

SAE Viscosity Number	Viscosity Range, Saybolt Univ., Sec. at 130°F. Min.	at 130°F. Max.	at 210°F. Min.	at 210°F. Max.
10	90	less than 120	—	—
20	120	less than 185	—	—
30	185	less than 255	—	—
40	255	—	—	less than 80
50	—	—	80	less than 105
60	—	—	105	less than 125
70	—	—	125	less than 150

TABLE V
New Crankcase Oil Classification
(Effective Oct. 3, 1950)
SAE Recommended Practice

The SAE Viscosity Numbers constitute a classification for crankcase lubricating oils in terms of viscosity only. Other factors of oil character or quality are not considered.

Viscosity numbers without an additional symbol are based on the viscosity at 210°F.

Viscosity numbers with the additional symbol "W" are based on the viscosity at 0°F.

The viscosity of oils included in this classification for use in crankcases shall be not less than 39 seconds at 210°F. Saybolt Universal.

SAE Viscosity Number	Viscosity Range, Saybolt Univ., Sec. at 0°F. Min.	at 0°F. Max.	at 210°F. Min.	at 210°F. Max.
5W	—	4,000	—	—
10W	6,000 (Note A)	less than 12,000	—	—
20W	12,000 (Note B)	48,000	—	—
20	—	—	45	less than 58
30	—	—	58	" " 70
40	—	—	70	" " 85
50	—	—	85	" " 110

Note A: Minimum viscosity at 0°F. can be waived provided viscosity at 210°F. is not below 40 Saybolt Seconds Universal.

Note B: Minimum viscosity at 0°F. can be waived provided viscosity at 210°F. is not below 45 Saybolt Seconds Universal.

In the case of prediluted oils, SAE Viscosity Numbers by which the oils are classified shall be determined by the viscosity of the undiluted oils.

Wherever the SAE Viscosity Numbers are used on prediluted oils, the container labels should show in some suitable manner that the SAE number applies to the undiluted oil.

SAE Viscosity Classification

Although various type motor oils are available to meet minimum performance levels, they must also be classified according to viscosity grades since oil viscosity is still a very important factor in lubrication.

The SAE has set up new viscosity classifications for motor oils. These limits were put into effect October 3, 1950 and the old classifications became void on April 3, 1952. A comparison of the old and new classifications is shown as Tables IV and V. The period overlapped by the two classifications was to provide sufficient time for the supplier to change manufacturing limits.

SELECTION OF A MOTOR OIL

It is hoped that the preceding discussion has clarified the motor oil classification as to the reasons for having a large number of different types and why each type has a definite minimum performance level. The primary improvement in heavy duty oils has been an increase in detergency level. In many cases the additives used to improve the detergency level also impart some inherent oxidation stability and corrosion preventive properties. The question naturally arises as to which oil to use in a truck or bus engine.

In selecting gasoline as discussed in the previous issue of LUBRICATION it was mentioned that the octane of gasoline need not exceed appreciably the octane requirement of the engine. The same principle is generally true in the selection of a motor oil; its performance level need not exceed the engine requirement. Based on the API designations a selection may be made as follows:

"DS" — Usually above the current heavy duty performance level oil, — such as Supplement 1 oils.

"DG" }
"MS" } — Current heavy duty performance level oils.

"MM" — Quality straight mineral oils containing oxidation stabilizers.

"ML" — Quality straight mineral oils.

Then if it is found basis experience that the particular service requires a higher performance level select an oil that is one level higher. It is not possible to be more specific than this for the following reasons:

1. All engines are not equally sensitive to the effects of fuel composition on wear and deposits, and the lubricating oil is expected to overcome both these evils regardless of sensitivity.

2. The range of sensitivity within one engine may vary according to operating conditions.

3. Operations with the same type of equipment vary among the different fleets.

Since MIL-O-2104 level oils are generally recommended for truck and bus engines some oil suppliers market through their service stations, an oil of this performance level as a premium grade oil, so that the small fleet operator may have this type of product generally available.

Oil Drain Periods

An explanation of oil type classification is usually followed by questions regarding oil drain periods. Many feel that oil drain periods should be materially extended by going to higher performance level oils. This may not always be possible. The oxidation stability at the MIL-O-2104 level appears to be sufficient for automotive engine service. The improved heavy duty oils are required to provide better engine cleanliness and less extensive wear, however, their improvement in oxidation stability (inherent in some of the additive materials used) is not always required.

Heavy duty oils must be drained not because of oxidation but because of contamination. Heavy duty oils do not wear out but engine service imparts certain characteristics to the oil which with continued use may lead to excessive wear and reduced engine efficiency, with a resultant increase in fuel and repair costs. With use, oils are contaminated with carbon, metal particles, water, unburned fuel, dirt, dust, etc. Although oil filters partially remove some of these contaminants those that remain in the oil change its characteristics and impair its lubricating properties. The film of oil which originally was thick enough to provide proper lubrication and piston seal is thinned by the presence of water and fuel dilution. Compression losses are increased and blow-by and wear are accelerated.

A contaminated oil cannot perform its function of lubrication as abrasive materials are carried by the oil film between moving metal surfaces to become a cause of wear. A dirty oil will not cool as efficiently as a clean oil since dirt acts as an insulator. If the contamination rate exceeds the filtering or removal rate, such as occurs in light delivery service, the oil will soon drop out these materials and they will form engine deposits.

The drain period depends on many factors such as type of service, conditions of operation, design of the engine, maintenance and the fuel and oil in use. The period is best determined by studying the operation and the analysis of sufficient used oil samples at various mileages to obtain a representative condition of the oil. The longest drain periods are obtained when using the proper fuel and motor oil, with good maintenance and proper engine operation. Always drain crankcases,

differentials and transmissions with the lubricant hot for best removal of contaminants.

Caution must be exercised in commenting on used oil analyses, for example, note the two analyses shown as Table VI. These samples can be considered as having been subjected to the same sort of service with respect to type of engine, miles of operation and type of operation. Basis the analyses shown the two oils do not appear to be significantly different in condition. By carrying the analyses one step further and obtaining a spectrographic analysis on the ash forming material it may be noted, as shown in Table VI-A, that both oils contained lead which originated from leaded fuel combustion and in addition Oil No. 2 contained silicon. The presence of silicon usually indicates that dirt or dust has entered the crankcase of the engine. The most usual source of entry is through air leaks or improper maintenance of carburetor and breather air cleaners.

To many this may appear to be a minor point, therefore, the used oils were centrifuged and the contaminating material was removed. Photomicrographs, at 25 magnifications of these materials are shown as Figs. 9A and 9B. Note the soft sludgy appearance of the leaded fuel combustion products which were predominant in Oil No. 1 (Fig. 9A) and compare them with the hard coarse granular material removed from Oil No. 2 (Fig. 9B).

TABLE VI
Used Oil Analyses
MIL-0-2104 Oil From Automotive Gasoline Engines

OIL NO.	1	2
Appearance	Very dark gray-green liquid	Very dark gray-green liquid
Odor	Normal Used	Normal Used
Water, %	Trace	Trace
Viscosity, SUS @ 100°F.	450	448
Free Carbon, %	0.07	0.03
Neutralization Number	0.45	0.36
Ash, %	0.75	0.90

TABLE VI-A

Oil No.	1	2
Spectrographic Analysis Major Foreign Components	Lead	Lead, Silicon

These materials were placed on polished steel specimens of 670 Brinnel hardness. A drop of unused oil was added and the mass was rubbed across the steel surface by means of a wax stick (light pressure.) The effect on the steel surfaces may be noted in Fig. 10. Would you continue to use Oil No. 2 in your engine?

The reputable oil marketer when he insists on oil drains is not trying to increase oil sales. He knows that a few extra oil changes which are relatively economical result in a saving in costly repairs. He is helping increase the life of your engine.

ENGINE BEARINGS

Diagnosis of bearing failures must be approached with full knowledge of all possible causes. Cases of engine bearing failures have been noted which although they appeared to have been caused by faulty lubrication, were definitely due to improper servicing and maintenance. Some of these failures seem to be premature fatigue failures while others seemed to indicate corrosion. Improper servicing in many cases is not due to negligence but rather to lack of knowledge as to how bearings and shafts function with respect to each other.

The majority of the failures occur in conjunction with replacement inserts installed at the time of engine overhaul. Engine owners and operators tend to blame the lubricant for their difficulty, although it has been conclusively shown that the majority of bearing failures generally are mechanical and associated with bearing design i. e. an unloaded upper half of a main bearing with its full oil groove operating with an ungrooved matching lower half as shown in View A of Fig. 11.

A typical early failure presented as View B shows a broken region and many hairline cracks on the mating half. Further service leads to the condition shown in View C. This last condition is that which leads to the accusation of the lubricant "corroding" the bearing: unfortunately, visual diagnosis cannot verify or deny this allegation. Microscopic examination however definitely shows these failures to be the result of metal fatigue.

An explanation advanced for the failure of an initial set of bearing inserts of this type is a hydraulic phenomenon that may cause a "water-hammer" at certain engine speed and loads which tends to produce high unit loads sufficient to fatigue the bearing alloy.

Another reason for such failures is that the lubricant will generally attempt to cut its own groove. Unfortunately when this occurs the undisturbed bearing surface is so drastically overloaded that it quickly pounds out.

A third explanation is that localized fatigue

Figure 9A — Material Centrifuged from Oil No. 1.

predicates a build-up of dirt or other abrasive material at the parting face of the assembled bearing. This dirt is carried into the solid insert and there disrupts oil films, displaces bearing metal, raises temperatures and fatigues bearings.

The preponderance of bearing failures have involved replacement inserts. The failure pattern shown in Fig. 11 is believed to be caused by crankcase journal "camming" or ridging. The ridge gradually forms on the shaft because of uneven wear rates between the part of the journal in contact with the partial oil groove and the rest of the journal which runs against the solid bearing. The original bearings will usually conform to the change in journal contour but new bearing shells installed on a shaft will quickly fail in the center zone from overload fatigue. Such a ridge can be extremely slight and it is possible that on a highly polished shaft, it might be almost imperceptible to the eye and may not be measurable with ordinary mechanics' tools (0.00075 inches or less). This ridge formation should be removed before installing replacement inserts. In the known absence of a journal ridge, the failure of replacement bearings would be attributable to causes similar to those destroying original bearings. The use of various bearing metal combinations have helped reduce this problem.

This experience has made it obvious that a perfunctory glance at failed engine bearings may lead to erroneous conclusions regarding the cause of failure. Therefore, unless other engine conditions definitely establish the cause of failure, the failed bearings should be examined microscopically by a qualified observer. To derive the most meaning from microscopic observation, some sound bearing metal should still be present on the steel back.

HYDRAULIC POWER TRANSMISSIONS

Hydraulic power transmissions may be classified as being either hydrokinetic and hydrostatic or positive displacement types. The hydrokinetic type is the one most generally used in both industrial and automotive applications. This type can be further divided into five groups, that is, fluid coupling, single stage, two stage, three stage torque converters and combination converter couplings. The fluid coupling does not multiply torque, but the others do with an increase in torque multiplication which increases with the number of stages.

In automotive service hydrokinetic type transmissions are usually coupled either integrally or

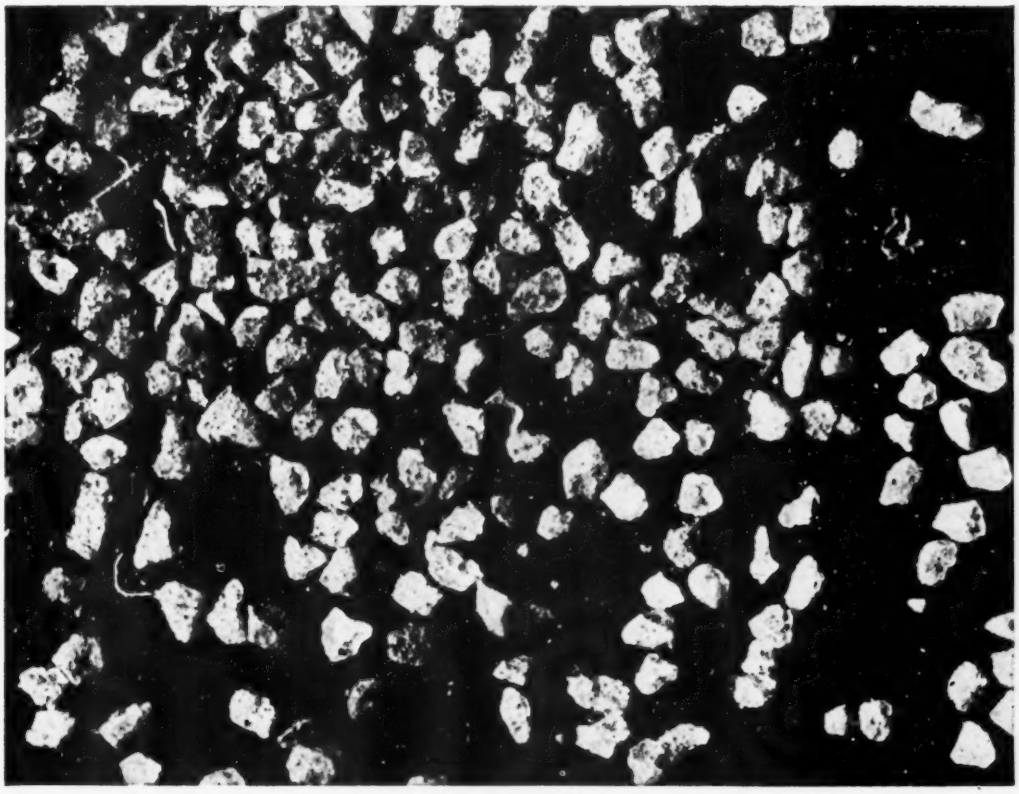


Figure 9B — Material Centrifuged from Oil No. 2.

independently with a gear box transmission. The gear box portion of these transmissions may be mechanical, semi-automatic or fully automatic. In the semi or fully automatic type the control is actuated by electrical, hydraulic or pneumatic means.

Each group of hydrokinetic transmissions requires certain fluid medium characteristics for proper operation. The physical and chemical characteristics that should be considered with respect to the function of the fluid in these units are briefly summarized as follows:

Function	Fluid Characteristics
Power Transmission	Viscosity, specific gravity, volatility.
Cooling	Specific heat, specific gravity, wetting action, viscosity.
Lubrication	Viscosity, EP properties, wetting action.
Seals	Viscosity, chemical or physical attack.
Corrosion Prevention	Oxidation stability, acidity, rust inhibition.

The sensitivity of the different types of these units to the above characteristics varies widely and is beyond the scope of this article.

In view of the number of hydraulic transmissions in use in the automotive field inquiries are usually made regarding classification of these units by similar types. In an effort to clarify this situation this information has been compiled as shown in Table VII. Practically all of these units have been discussed in great detail in previous issues of LUBRICATION. Torque converters have been used in busses in city service for a number of years with satisfactory service. Last year a torque converter transmission was introduced as standard equipment for a milk delivery truck. Two automatic transmissions, one of which has been used for several years in small transit type busses, are now available for truck service. It will not be surprising to see most door-to-door or city delivery trucks equipped with automatic transmissions because of their simplicity and ease of operation and adaptability to one-man delivery operation.

Fluid Drive Fluid

The fluid to be used in equipment fitted with fluid couplings is marketed by the manufacturer

TABLE VII — AMERICAN AUTOMOVE

Type of Hydrokinetic Unit*	Transmission Name and Users	Gear Shifts During Acceleration	Mechanical Direct Drive	Fluid and Lubricants Required	Fluid Cooling Method
Fluid Coupling	FLUID DRIVE Chrysler De Soto Dodge	1	No	Fluid Drive Fluid SAE 10W Motor Oil	Radiation
	HYDRA-MATIC Oldsmobile (Whirlaway)	2	No	AQ-ATF Type A	Radiation
	Oldsmobile Cadillac Pontiac Nash Lincoln Kaiser Light GM Bus Hudson GM Truck	3	No	AQ-ATF Type A	Radiation
Three-Element Converter-Coupling	HYDROTORQUE White Bus	1	No	HD SAE 20 Motor Oil	Water
	STUDEBAKER Studebaker	1	Yes	AQ-ATF Type A	Air
	FORDOMATIC Ford MERCOMATIC Mercury	1	No	AQ-ATF Type A	Air
	INTERNATIONAL CONVERTER International Harvester	1	No	SAE 10W Motor Oil	Air
Four-Element (Polyphase) Converter Coupling	FLUID-TORQUE Chrysler De Soto	1	No	Fluid Drive Fluid or SAE 10W Motor Oil	Water

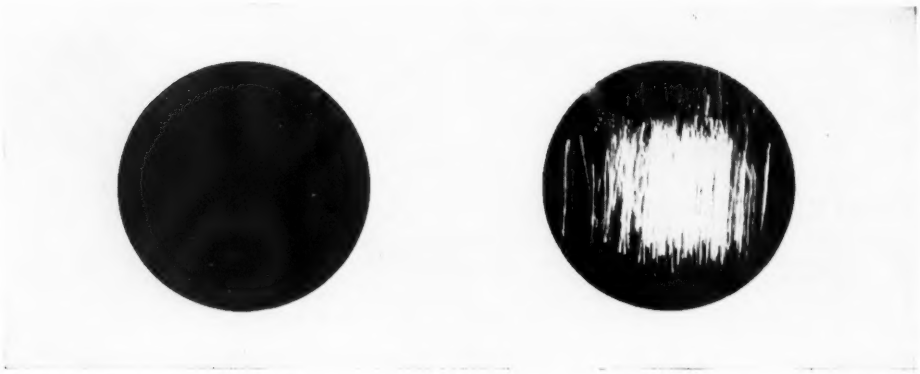
*In Schematic Diagrams "P" represents pump "S" represents stator or reactor and "T" represents turbi fluid fl

OMOWE AUTOMATIC TRANSMISSIONS

Type of Hydrokinetic Unit*	Transmission Name and Users	Gear Shifts During Acceleration	Mechanical Direct Drive	Fluid and Lubricants Required	Fluid Cooling Method
Two-Stage Converter-Coupling	ULTRAMATIC Packard	0	Yes	AQ-ATF Type A	Water
Two-Stage Converter	GM VEE TYPE GM Truck and Coach	0	Yes	Torque Fluid	Air
Five-Element (Polyphase) Converter Coupling	DYNAFLOW Buick	0	No	AQ-ATF Type A	Water
	POWERGLIDE Chevrolet	0	No	AQ-ATF Type A	Water
Three-Stage Converter	SPICER TYPE GMC, Twin Coach, Mack, ACF, Aero-Coach, Reo and White Buses	0	Yes	Torque Fluid Grease Gear Oil	Air or Water
	TWIN DISC	0	Yes	Torque Fluid	Air or Water

s turbine fluid flowing clockwise.

The Texas Co.—Revision of April 2, 1952



Oil No. 1 Oil No. 2

Figure 10 — Abrasiveness of Material Centrifuged from Used Oil Polished Steel Specimens 670 Brinnel.

of the vehicles under the name Fluid Drive Fluid. These couplings under normal operation require no service, that is, level checking or checking of the fluid is not required. However, if leakage is evident, they must be serviced by a qualified mechanic.

Torque Fluids

The torque converter fluids originally used were kerosine, No. 2 household fuel oil or Diesel fuel. In diesel-engined coaches the converters were connected to the fuel oil tank. Experience soon indicated that these were not the proper materials for this service because of oxidation, deposit formation, insufficient viscosity, cavitation, foaming and chemical and physical attack of turbine parts and seals. Therefore specially designed "torque fluids" were developed for this application. Typical characteristics of one of these products are as follows:

Gravity °API	26.4
Flash, PM °F.	300
Viscosity, SUS @ 100°F.	63.1
Viscosity, SUS @ 210°F.	35.1
Pour, ASTM, °F.	—45
Foam Test, CRC	None
Rusting, Salt & Distilled Waters	None

With the advent of the GM V Type Hydraulic Transmission wherein the angle-drive bevel gears are lubricated by the torque fluid, a higher viscosity product appeared to be advisable. A new specification was advanced which required the same oxidation stability and foam resistance of these fluids but raised the viscosity limits as follows:

Viscosity SUS @ 100°F.	95-105
Viscosity SUS @ 210°F.	39 Minimum

This specification allowed the use of SAE 5W heavy duty oils. The operator is still permitted to use the lower viscosity torque fluids if he desires since service experience in most cases shows satisfactory performance on these "lighter" fluids.

Other manufacturers of torque converters for busses will no doubt soon have models combining the angle-drive gear section with the torque converter section all lubricated and operated by one fluid.

Lubrication of Other Torque Converter Parts

The pilot and throwout bearings of the friction clutch or clutches and the front and outer ball bearings of the converter pump are lubricated satisfactorily with regular application of moderate amounts of a high melting point smooth-textured sodium soap grease having high resistance to leakage and completely free of non-lubricating and abrasive fillers. An NLGI Grade 2 of this type of grease is adequate for moderate operating conditions while an NLGI Grade 3 is better for heavy duty service.

Those units having a separate angle-drive appear to be best satisfied by use of an SAE 50 grade good quality engine oil. At present all coach manufacturers either directly recommend or permit use of a heavy duty motor oil of the MIL-O-2104 level. Ordinary gear oils and hypoid gear oils should not be used.

Air cylinders, linkages and associated elements of the control system are variously lubricated with non-petroleum hydraulic brake fluid, graphite grease or engine oil depending upon the specific design or manufacturer.

Automatic Transmission Fluids Type A

Many of the automatic transmissions were designed and developed using a fluid such as the highly "specialized" Automatic Transmission Fluid

Type A products generally available and use of such oils is recommended by the vehicle manufacturers. Reports from field service indicate that SAE 10W motor oils also have been used for this service since their viscosity is approximately the same as that of the qualified fluids. This practice is not generally recommended however, since motor oils do not contain all of the characteristics incorporated in an Automatic Transmission Fluid Type A product. These characteristics are high oxidation resistance, foam resistance, oiliness, some EP properties and a very high viscosity index so necessary to maintain the proper viscosity through a wide temperature range for best operation particularly when hydraulic controls are actuated by the fluid. Another feature is the low cold test requirement not possessed by motor oils.

Fluids of this type must meet rigid physical and chemical characteristics, and must be satisfactory in special engine and transmission tests, conducted at an independent laboratory and must pass an actual road test before they receive AQ-ATF qualification numbers for Type A Fluids.

Automatic Transmission Servicing

In servicing these units the most important considerations are to:

(a) use the *proper* fluid (otherwise premature parts failures may occur);

(b) follow a proper periodic filter and fluid cooler maintenance program; and

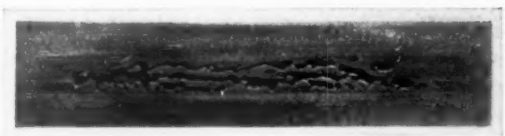
(c) drain at regular intervals and immediately correct leaks and seal difficulties.

To avoid overheating don't overfill or underfill these units. Service experience shows that in cases where these simple service and maintenance procedures are followed transmission life has been very satisfactory.

CONVENTIONAL TRANSMISSIONS

Straight mechanical or conventional transmissions are used in most truck service and inter-city bus service where sustained high speed operation prevails. The trend in lubrication of these units is increasing toward the use of SAE 50 engine oils in the high quality, heavy duty classification. The good oxidation resistance, EP properties and anti-corrosive and anti-rust properties of these oils make them ideally suited for this service. However, in transmissions, particularly auxiliary units wherein high EP properties are required gear lubricants having these properties should be used. These lubricants are discussed more fully under "rear axles."

View A
New Main Bearings
Upper (left) — Lower (right)



View B
Early Failure Pattern

View C
Complete Failure Pattern

Figure 11 — Typical Bearing Fatigue Failures

Transmissions must be drained at regular intervals. This fact is not usually appreciated. The reasons for draining are primarily the same as those for engine oils. In addition, however, when straight mineral oils are used in these units the prevailing high temperatures may cause oxidation to occur. Where lubricants have been used to the point where oxidation and contamination may have become excessive it is good policy to flush the gear case before adding a fresh lubricant charge. Oxidation materials from the previous charge and metal particles (particularly those containing copper) when introduced to the fresh lubricant will act as oxidation promoters reducing the possible service life of the new charge of lubricant. When lubricants are used close to their maximum service life, drain periods should be reduced if the severity of operating conditions warrants, otherwise "coking" difficulties may be experienced. If power takeoffs are added to a transmission a greater volume of lubricant will be required. *Don't operate with the lubricant level too low.*

REAR AXLES – GEAR LUBRICANTS

The knowledge of gear lubrication has increased tremendously in the last half century. In the years following early developments of the automotive industry, rear axle lubrication received little attention. Gears were plain and simple and any heavy oil stock was considered to be satisfactory. Oil changes were no problem; leakage was sufficient to take care of a lubricant change. With such gears rather wide adjustments were permissible without failure although the noise level at times became annoying. All sorts of "fillers" were added to the lubricant to cushion shock loads and reduce noise.

As the truck and bus industry developed it became necessary to widen the range of speed reduction (torque multiplication) to reduce the size of the unit and to lower drive shafts to make a better designed vehicle with greater stability and utility. Many of these changes led to increased gear tooth loads and introduced sliding action along with pressure. Today rear axles contain most of the common types of gears singly or in combination depending on the service requirement. In all rear axles one stage requires transmission of power through perpendicular shafts (or askew, angle-drive) using either straight bevel, spiral bevel, hypoid or worm and wheel gear combinations and some form of differential action. To gain greater speed reduction or torque multiplication some of these combinations may be combined with spur, helical and herringbone parallel shaft reductions. To further complicate the mechanism but to obtain a wider range of service, levers and appropriate gear sets may be included to provide more than one speed reduction. It is obvious that these complex units impose definite requirements on the lubricant. Also if lubricant characteristics are impaired through use, the lubricant must be changed promptly to avoid costly repairs or low service life.

To take care of this multiplicity of possible combinations of gears the Lubricants Committee of the Division of Marketing of the API have set up gear lubricant classifications which are used by the SAE, these are as follows:

"*Regular Type Gear Lubricant* – This term designates gear lubricants generally suitable for use in automotive transmissions and in most spiral-bevel and worm-gear differentials."

"*Worm Type Gear Lubricant* – This term designates gear lubricants generally suitable for use in truck-type worm-gear rear axles under very severe conditions of service."

"*Mild Type EP Gear Lubricant* – This term designates gear lubricants having load-carrying properties suitable for many automotive transmissions and spiral-bevel differentials under severe conditions of speed and load."

"*Multipurpose Type Gear Lubricant* – This term designates gear lubricants having load-carrying properties suitable for hypoid gear and other types of differentials and transmissions."

These definitions are somewhat broad and include all of the gear lubricants that are generally suitable for the various services normally encountered. There are no definite restrictive limits for these lubricants except in the Multipurpose classification. Here the Military MIL-L-2105 Specification "Lubricant, Gear, Universal," sets up definite requirements for qualification. The lubricants so qualified must not only comply with definite viscosity as well as corrosion and rust protection requirements in the SAE 75, 80, and 90 grades but must also pass definite storage stability, foaming and axle tests in the SAE 90 grade. Present requirements do not include the SAE 140 grades in this specification. Some suppliers, in addition to qualifying their products, evaluate these lubricants by extensive special road and field tests to assure proper product quality before marketing. The SAE viscosity classifications of gear lubricants revised by the Fuels and Lubricants Technical Committee January 1952 are shown as Table VIII.

The same reasons as noted under motor oils and transmissions apply to rear axle lubricant changes. Although in most cases rear axle life appears to be equal to vehicle life, improper service, maintenance and lubrication have led to premature failures.

TABLE VIII

SAE Viscosity Classifications for Transmission and Axle Lubricants — Saybolt Universal Seconds

SAE Viscosity Number	0°F MIN	0°F MAX	210°F MIN	210°F MAX	Consistency—Must Not Channel in Service at °F.
75	—	15,000	—	—	—40
80	15,000[a]	100,000	—	—	—20
90	—	—	75	120[b]	—10
140	—	—	120	200	+20
250	—	—	200	—	—

[a] The minimum viscosity at 0°F may be waived if the viscosity is not less than 48 SUS @ 210°F.

[b] The maximum viscosity at 210°F may be waived if the viscosity is not greater than 750,000 SUS at 0°F (extrapolated).

CHASSIS

All of the chassis bearing points require periodic renewal of the lubricant to minimize wear, reduce friction and eliminate noises. The lubricant used should be readily pumpable since the lubrication points are equipped with grease fittings. It should form a tough, durable long lasting film on the bearing parts. It should be adhesive and cohesive so that it will not readily "run out" of bearings. It should withstand heavy hammering blows and loads without jolting or squeezing out of bearings. It should resist water washing and seal against entry of dirt, water and other contaminants and should not permanently change materially in texture and consistency under these severe conditions. It is obvious that a lubricant developed specifically for this purpose is required. Such products are generally available.

The usually accepted renewal period is at 1000 mile intervals, however, under unusually severe or mild conditions it may be necessary or possible to vary from the general recommendation. Cleanliness and application without severe pressure at points involving seals are the only precautions necessary in chassis lubrication. In other words, clean all fittings before applying grease, don't over lubricate and clean off excess grease.

Normally oil can points should be lubricated at the same time as the grease points. An SAE 20 grade motor oil is usually recommended for this application and in most cases the type used for engine lubrication is suitable.

Some fans, distributors and generator and starter bearings require grease lubrication. Good quality ball bearing greases or multi-purpose type greases are usually best suited for these applications although cup greases and petroleum jellies are often used. The main cautions are again cleanliness and don't overlubricate in quantity but lubricate at regular intervals.

Water pumps that require renewal of lubricant are best lubricated with special water resistant greases developed for this application.

Some controversy appears to exist with respect to spring lubrication, however, if the manufacturer's recommendations are followed no particular difficulties should be experienced. The friction between the spring leaves control the action and thereby the ride. Spring leaves which are laminated with special materials to regulate the interleaf friction usually do not require inner lubrication. All that is necessary is an outside spray as a protection against rust. Other types, usually all metal covered types, require a graphited product. The lubricant serves as an anti-rust agent, seals against entrance of dirt and other contaminants and is intended to regulate the interleaf friction. These graphite greases should be insoluble in water and water resistant. The general precautions are cleanliness, lubricate at chassis interval and don't over lubricate.

Hydrovacs that require lubrication are normally lubricated with a vacuum cylinder oil. Specific amounts are usually specified by the manufacturer and lubrication periods are usually 10,000 miles for 9½" single piston units and 20,000 miles for other units. Lubricate only with engine shut off and brakes released being particularly careful of cleanliness and amount of oil supplied.

When self lubricated compressors are used check oil level at the same time as the engine crankcase. Oil drains usually may be made at the same interval as the engine crankcase. The same oil used for the engine may be used for these units unless the manufacturer specifically recommends otherwise. Air chambers on brakes are generally of the diaphragm type and require no lubrication.

Anchor pins of certain type brakes are provided with tapped holes for lubrication fittings and are usually lubricated with the chassis lubricant to prevent binding action. Other types require lubrication only at time of brake inspection or relining when the pins should be cleaned and lubricated according to manufacturer's recommendations.

Slack adjusters are of two types and serve as a brake lever and act as a simple brake adjustment. The open screw-type adjuster requires no lubrication while the enclosed worm and gear type is equipped with a plug fitting for applying chassis lubricant at approximately 25,000 mile intervals.

FIFTH WHEEL

The truck tractor carries the front end of a tractor by means of a turntable or fifth wheel. This mechanism mounted on the rear of the tractor chassis consists essentially of a table with pedestal bearings which allow it to move freely on its axis. The tractor moves freely on the turntable pivot so that it may follow the tractor in any direction. Fittings are provided for the bearings at both ends of each shaft and for the table. The bearings are lubricated at the same frequency and with the same product as the chassis. Although a good chassis lubricant may be used for the turntable a graphite grease like that used for spring lubrication is more suitable in view of its greater water resistance, water insolubility and the action of the graphite filler.

STEERING GEAR

Power steering was supplied as original equipment for cars for the first time in 1951 on one make of car. The idea of power steering dates back over 75 years and has been previously applied to rugged off-the-highway trucks and military vehicles. At this writing the truck industry has not announced power steering as original equipment for on-the-highway vehicles but an announcement of this type should not be unexpected in the very near future.

Last year a bus was announced which is equipped with extensive hydraulic controls and includes power steering. This power steering unit is now also being supplied on another make bus. In these units the fluid not only acts as the actuating medium but must also lubricate the moving parts. The Automatic Transmission Fluid Type "A" products now generally available appear to be very suitable fluids for these units because of their characteristics as noted previously in discussing automatic transmissions.

The conventional steering gear boxes require various lubricants depending on the design of the unit, however, most of the units are suitably lubricated with chassis lubricants or gear oils. The frequency of lubrication is usually at the time of chassis lubrication. The important precautions are again cleanliness, don't overlubricate and don't use excessive pressure that will damage seals.

UNIVERSAL JOINTS — SPLINE SHAFTS

The universal joint comprises two yokes at right angles to each other and an intermediate member which may be either a cross, a block or a ring. Since in most applications the distance between points connected by shafts with universal joints will vary, splined-shaft mountings are used to permit sliding motion. Some of the constant velocity type joints allow for the sliding in the joint and splined mountings are not necessary.

Universal joints that are enclosed and mounted in back of the transmission gear box are usually lubricated by the gear box lubricant. Other universal joints may have an oil reservoir in the cross or trunnions. Some universal joints have sufficient lubricant capacity so that the original supply is good for the life of the vehicle or replenished after long periods of service such as 20-30,000 miles. A lubrication fitting is usually provided for this purpose, however, some types require disassembly for lubrication. A relief valve or hole is usually provided to prevent overlubrication and/or damage to seals. The slip joints (spline shafts) are always closed at one end by a disc or cap fitted to the yoke of the universal and at the other end by a packed seal and are usually equipped with independent lubrication fittings.

Universal joints are mainly lubricated with an SAE 140 grade oil but some require a grease. Slip joints are usually grease lubricated although some require an SAE 140 grade oil. Lubrication periods if not of the long period type should be at the time of chassis lubrication.

The main reason for relubrication of these automotive vehicle components is loss of lubricant and contamination. A few simple precautions in servicing these units will assure trouble-free long service life. These are: lubricate at manufacturer specified periods, clean dirt from fittings before lubrication and do not overlubricate. In lubricating universal joints that require disassembly remove all used lubricant, wash parts, dry and relubricate immediately when dry.

WHEEL BEARINGS

The most difficult lubrication point on a vehicle is the wheel bearing since it not only involves the proper application of a suitable lubricant but also requires the mechanical know-how of handling and adjusting a precision mechanism. Each phase of the process is equally important to attain maximum bearing life. An anti-friction bearing will not wear out if it is properly adjusted and kept free of abrasive materials and other contaminants that interfere with the rolling action. Normal termination of bearing life is by failure of the contacting surfaces.

The bearing manufacturers have load and speed rating maximums for each specific type and size of bearing which if not exceeded result in a definite expected bearing life.

It is the responsibility of the vehicle designer to consider these maximum load and speed ratings and applying the proper safety factors to assure long life. The greater the margin of safety applied the longer the expected life will be. The operator's

considerations for maximum wheel bearing life are equipment loading, type of operation and service and maintenance.

WHEEL BEARING LUBRICATION

The main purposes of a fluid lubricant for wheel bearings are to prevent rust and to facilitate as easy rolling as possible. Therefore all that is necessary is a thin film of oil which should be free from contamination that may cause wear, have high resistance to oxidation, gumming and deterioration and should not corrode any of the parts. Since the function of an antifriction bearing is to reduce friction the viscosity of the lubricant should be as low as possible to minimize fluid friction. Normally as speed is increased the viscosity of the oil should be decreased, of course within limits, let us say for example 80 to 100 seconds Saybolt Universal at the operating temperature. With roller bearings when end thrust develops to a large extent or where pressures may be high an increase in viscosity appears to be desirable.

One manufacturer has recognized that oils are very desirable wheel bearing lubricants and markets conversion kits for use on both live and dead axles. Service experience reported on these units is very favorable, however, extreme care must be exercised in installing and maintaining the oil seals since leakage difficulties would be more serious than if grease were in use.

GREASE LUBRICATION

A suitable wheel bearing grease must provide lubrication without affecting the low frictional characteristics of the bearing; as it functions as a seal to prevent the entry of foreign matter it must not tend to leak out of the bearing. A suitable grease for this application must resist separation and it should be free from acid-forming tendencies, and fillers or materials which might give rise to oxidation, corrosive reaction or decomposition. It should not be too fibrous or stringy otherwise starting and running friction may be affected. The texture also can affect the retention on the cage and rollers. High stability, rather high melting point, and no hardening, caking or excessive softening over a wide temperature range are other desirable characteristics. Wheel bearings operate mainly below 150°F., however mechanical conditions can quickly arise that will raise temperatures above 250°F.

Greases are divided into different classes according to their base and soap type, the most common are calcium, sodium, mixed base, lithium, aluminum, potassium and lead soap types. Calcium-sodium (mixed-base), sodium soap, and lithium soap greases are most widely used for wheel bearing application. Calcium soap greases of the normal type channel readily and should not be used above 150°F. maximum since above this temperature water used in their manufacture is driven off ultimately causing grease breakdown. Hence they are not suitable wheel bearing greases. Sodium soap greases do not break down at the higher temperatures, however, they will usually be fibrous in nature unless special processes are used in manufacture that minimize this fibrousness, to make them suitable for heavy duty usage. Lithium soap greases usually have very high melting points and are very resistant to water washing. This type is coming to be referred to as a so-called multi-purpose grease. Mixed bases of calcium and sodium produce products with good resistance to leakage, low starting torque in cold weather, good high temperature stability and shear stability.

Considerable time, money and effort has been and is being spent on developing specialized greases and numerous tests are available in the laboratory that measure the various properties of low temperature torque, oxidation resistance, breakdown resistance, stability, water resistance and leakage.

In reviewing the vehicle manufacturer's recommendations for wheel bearing repack periods it may be noted that wide differences in mileages exist. To some this may be an indication that the lubrication of wheel bearings is a controversial subject. Actually this is a poor argument since these mileages are usually based on experience and are made to coincide with known servicing mileages. The type of lubricant recommended and the definiteness of this recommendation also influence the repack recommendation. Many manufacturers also are very conservative and reduce their recommendation to cover some of the more severe service conditions and the inferior quality lubricants some operators are prone to use.

The practical repack period is at the time of brake shoe relining. If other conditions arise that require wheel pulling and the possibility of dirt, water or other contaminant entry exists it is wise to clean and repack the bearings even though the lubricant appears to be in good condition. It is recognized that many operators do not attain this practical repack period. The reasons are usually severe overloading in service which may or may not be coupled with features of improper packing, improper bearing adjustment, overpacking, wrong lubricant used, severe road conditions, excessive water washing, improper application of the lubricant and poor seals or seal maintenance.

Much has been written about the method of cleaning, inspecting and repacking wheel bearings and need not be repeated again, however, even the most experienced at times get lax and forget the

TABLE IX

Conditions Which Can Affect Wheel Bearing Lubrication and Performance

1. Inadequate cleanliness.
2. Bearing parts dropped.
3. Bearing parts distorted or chipped in removal or installation.
4. Bearing parts damaged by contact with wrong type of surface. (Use soft clean lintless cloth)
5. Seals damaged by dragging wheel on spindle in removal or mounting.
6. Use of dirty or wet air to dry bearings.
7. Spinning bearings with air while drying.
8. Handling of contact surfaces when dry. (Body acids)
9. Failure to inspect and repack bearings immediately after drying.
10. Inadequate inspection. Use of bearing showing spalling, flaking, rust, excessive wear, brinneling, loose or misaligned cups in hubs and presence of bits of old grease, dirt, chips and cleaning solvent.
11. Use of mismated parts. Replace whole bearing (cup and cone) when one part fails.
12. Use of bad or wrong type of seal or omitting altogether.
13. Improper seal installation.
14. Poor wheel bearing or wheel design.
15. Improper bearing adjustment. Too loose or too tight.
16. Use of wrong grease, dirty grease (usually user's fault), and mixing of greases.
17. Improper lubricant application.
18. Insufficient repack frequency for type of service.
19. Dragging brakes.
20. Overfilling of wheel hub cavity.

cautions necessary to accomplish a satisfactory wheel bearing lubrication job. Things that adversely affect wheel bearing lubrication and performance are shown as Table IX.

The chief controversy in wheel bearing lubrication is: how much grease should be put in the wheel hub? Some grease is required to prevent rusting. The spindle should also be very lightly smeared with the grease for the same reason. Some feel that the level should be high enough to help prevent excessive loss from the bearing. The amount of grease placed in the hub cavity is left to the discretion of the operator but *don't overfill.* Overfilling is harmful since the expansion of grease resulting from temperature rise during operation can create enough pressure to force the grease past seals on to the brake lining. Also the spinning of the wheel around a stationary spindle will create a whipping action in the grease. This whipping will aerate the grease further expanding its volume, working the grease unnecessarily to create heat and impose a drag on the wheel. Whipping and aeration may cause texture, color and consistency changes in many greases.

Proper wheel bearing lubrication is important from an operating standpoint since bearing failures not only cause expensive road calls but may also lead to accidents.

SUMMARY

It may be noted that as new bus and truck equipment designs materialized, fuels and lubricants were concurrently developed to meet the new requirements. Fifty years ago when both the automotive and petroleum industries were in their infancy new advances were made independently. All concerned soon recognized that lubricants are the blood streams that maintain the life of moving mechanisms and that fuels can cause engine indigestion and give rise to mechanical ills. As a result there has been a constantly increasing closer association and cooperation between the petroleum and automotive industries in providing for new designs and proper care of existing equipment.

The quality, dependability and outstanding performance characteristics of modern fuels and lubricants are the result of extensive research, careful laboratory testing and long periods of service operation under a wide variety of conditions. However if these products are not used properly all of the time, money, and effort spent in developing them is wasted.

The most important phase of preventive maintenance, to attain the ultimate goal of satisfactory, economical performance and long vehicle life, is the application of the right amount of the proper lubricant at the right place at the time it's needed.

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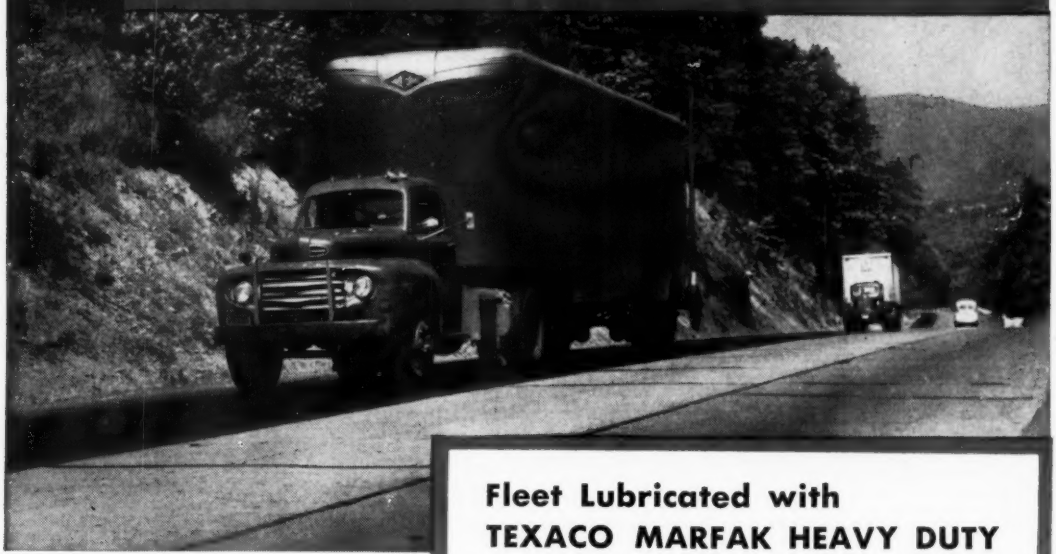

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